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The size effect of the tensile strength of inorganic glass fibers

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It is known that the tensile strength of glass fibers usually is one or two orders of magnitude higher than that of bulk glasses with the same chemical composition. It is also known that the tensile strength of the glass fibers depends on the fiber diameter, i.e., there is a size effect of the strength of glass fibers. But the questions are: What are the physical sources of the size effect of the glass strength? How much of the size effect is caused by the bulk structural factor, and how much is caused by the surface factor (e.g. surface defects and flaws). Both factors are sensitive to the fiber diameter that is determined by fiber forming conditions such as drawing speed, drawing force, cooling rate and so on. In this presentation I attempt to give some answers to the above-mentioned questions based on both literature data and recent experimental findings obtained in our laboratory. To do so, I will discuss the relationships among the tensile strength of glass fibers, the frozen-in glass structure, and its relaxation behavior in glass fibers. To find these relationships, we carry out fiber drawing experiments, physical aging of fibers and calorimetric measurements. In addition, we measure the optical birefringence and viscosity, and tensile strength of glass fibers. Finally I try to give some suggestions about how to improve the fiber strength.